# *"The Modular Open Systems Approach (MOSA)"*

### *Presented to the Executive Program Managers Course*

## *13 August 2004*

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## Open Systems Joint Task Force
## OUSD (AT&L), Defense Systems
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## www.acq.osd.mil/osjtf

# Agenda

- DoD Open Systems Policy & Vision
- OSJTF Background and Mission
- Open Systems Concepts
- Standards and Architectures
- Systems Engineering, Logistics and Cost
- Application Examples
- MOSA Program Assessment and Review Tool
- Applying MOSA to Systems of Systems (SoS)
- Summary

# USD(AT&L) MOSA Implementation Memo

THE UNDER SECRETARY OF DEFENSE

3010 DEFENSE PENTAGON
WASHINGTON, DC 20301-3010

APR 5 2004

ACQUISITION,
TECHNOLOGY
AND LOGISTICS

MEMORANDUM FOR: SEE DISTRIBUTION

SUBJECT: Amplifying DoDD 5000.1 Guidance Regarding Modular Open Systems Approach (MOSA) Implementation

A key enabler in the Department's focus on joint architectures and evolutionary acquisition is a modular, open systems approach (MOSA) to systems acquisition. MOSA is an integrated business and technical strategy that employs a modular design and defines key interfaces using open standards. MOSA is based on a robust systems engineering approach as defined in my Policy for Systems Engineering in DoD, dated February 20, 2004. MOSA enables programs to: 1) design for affordable change; 2) employ evolutionary acquisition and; 3) identify key modules and interfaces of a system's architecture. The Department's intent is to use open architectures to rapidly field affordable systems that are interoperable in the joint battle space. A required step in this direction is to ensure each Service has a coordinated business and technical approach to MOSA across their respective programs that will ultimately support the progression towards joint integrated warfare.

The purpose of this memorandum is to amplify and expand the policy for implementation of MOSA as set forth in DoDD 5000.1, dated May 12, 2003. Paragraph E1.27 states that, "A modular, open systems approach shall be employed, where feasible." Commencing October 1, 2004, all programs subject to milestone review shall brief their program's MOSA implementation status to the Milestone Decision Authority (MDA) to determine compliance. Programs not complying with MOSA implementation guidelines shall provide justification or a migration plan to the MDA for achieving compliance. This policy will be included in the next revision of DoDI 5000.2.

The Open Systems Joint Task Force (OSJTF) is my lead for MOSA and has developed a Program Manager's Guide that provides principles and guidelines for implementing MOSA in new and current programs. In addition, OSJTF has adapted the Office of Management and Budget (OMB) Program Assessment and Rating Tool (PART) in assessing MOSA implementation. Each program will present the results of their PART assessment, using the results generated by the tool, at all major milestone and program reviews. The guide and the PART are available at http://www.acq.osd.mil/osjtf/html/mosa_assessment.html.

> *"The Department's intent is to use open architectures to rapidly field affordable systems that are interoperable in the joint battle space. A required step in this direction is to ensure each Service has a coordinated business and technical approach to MOSA across their respective programs that will ultimately support the progression towards joint integrated warfare."*

> *"Commencing October 1, 2004, all programs subject to milestone review shall brief their program's MOSA implementation status to the Milestone Decision Authority (MDA) to determine compliance."*

> *"...OSJTF has adapted the Office of Management and Budget (OMB) Program Assessment and Rating Tool (PART) in assessing MOSA implementation. Each program will present the results of their PART assessment, using the results generated by the tool, at all major milestone and program reviews."*

# MOSA Implementation Instructions from the Director of Defense Systems

OFFICE OF THE UNDER SECRETARY OF DEFENSE

3000 DEFENSE PENTAGON
WASHINGTON, DC 20301-3000

JUL 0 7 2004

ACQUISITION
TECHNOLOGY
AND LOGISTICS

MEMORANDUM FOR: SEE DISTRIBUTION

SUBJECT: Instructions for Modular Open Systems Approach (MOSA) Implementation

A Modular Open Systems Approach (MOSA) is a means to assess and implement, when feasible, widely supported commercial interface standards in developing systems using modular design concepts. It is an integral part of the toolset that will help DoD achieve its goal of providing the joint combat capabilities required in the 21st century, including supporting and evolving these capabilities over their total life-cycle. The USD(AT&L) memorandum, dated April 5, 2004 states: "commencing 1 Oct 04 all programs subject to milestone review shall brief their program's MOSA implementation status to the Milestone Decision Authority (MDA) for compliance." The purpose of this memorandum is to describe how this requirement will be addressed for systems and systems-of-systems in the formal acquisition process.

Given the enabling relationship of a modular open systems approach to evolutionary acquisition, DoD acquisition programs should address Modular Open Systems Approach (MOSA) early in their program and acquisition planning, and should discuss MOSA implementation in the context of their overall Acquisition Strategy and to the extent feasible in the Technology Development Strategy. MOSA implementation issues should be identified and addressed via the IPT process and presented as issues to the MDA only when unresolved at a lower level.

The Open Systems Joint Task Force (OSJTF) is my lead for MOSA and has developed the Program Assessment and Rating Tool (PART) for your use in conducting your internal MOSA implementation assessments. Program Managers should either use the PART, or an equivalent method of assessment, to generate objective data on the success of their MOSA implementation. The OSJTF Program Managers MOSA guide and PART are available at http://www.acq.osd.mil/osjtf/html/mosa_assessment.html. Additionally, pertinent MOSA and PART information will be provided in the next update to the DoD Acquisition Guidebook.

*Purpose..... To describe how this requirement will be addressed for systems and SoS in the formal acquisition process*

*MOSA implementation issues should be identified and addressed via the IPT process and presented as issues to the MDA only when unresolved at a lower level.*

*Program Managers should use either the PART or an equivalent method of assessment to generate objective data on the success of their MOSA implementation.*

# OSJTF Background and Mission

- ➢ **Current Policy**
  - • "A modular, open-systems approach shall be employed, where feasible." (DoDD 5000.1)
- ➢ **Task Force Mission**
  - • Champion the establishment of a modular open systems approach (MOSA) as the preferred technical approach and business strategy for the acquisition of all weapon systems.
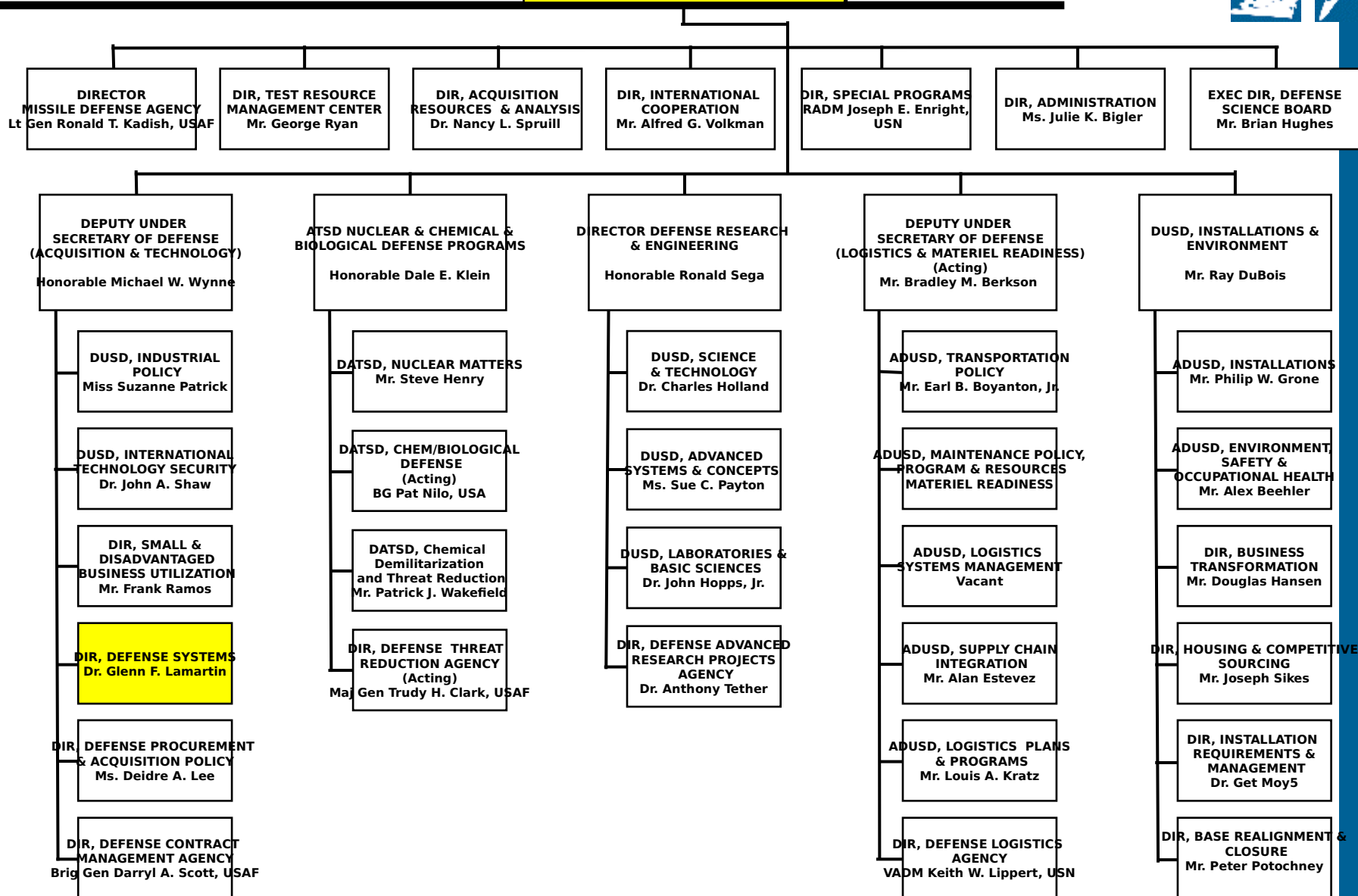- ➢ **Initial Scope**
  - • Weapons systems and platforms
  - • **Not C3I systems**, communications networks, nor non-real time data processing functions → now needs to address net-centric
  - • Hardware, software, tools and architecture
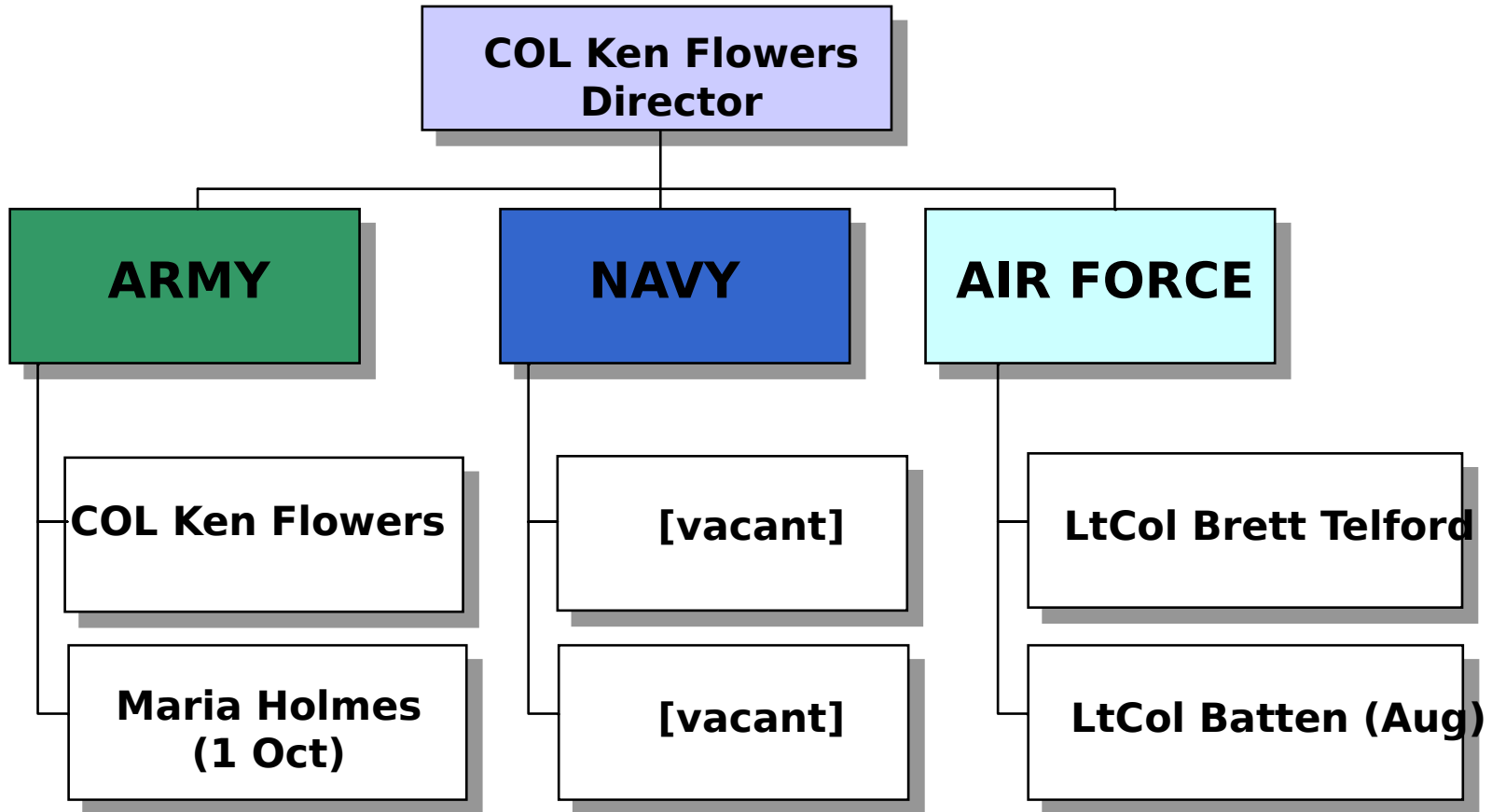  - • Electrical, mechanical, thermal, etc.

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# *OSJTF Staff*

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                    │     Director        │
                    └─────────────────────┘
          ┌───────────────┼───────────────┐
    ┌──────────┐   ┌──────────┐   ┌──────────────┐
    │   ARMY   │   │   NAVY   │   │  AIR FORCE   │
    └──────────┘   └──────────┘   └──────────────┘
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|------|------|-----------|
| COL Ken Flowers | [vacant] | LtCol Brett Telford |
| Maria Holmes (1 Oct) | [vacant] | LtCol Batten (Aug) |

Contractors:
Dr. Cyrus Azani            Mr. Dan Feliciano            Mr. Glen Logan
Mrs. Allison Fichera                Ms Kim Moore
Mr. Pete Cooper            Mr. Dwayne Hardy

# *MOSA Vision from the Top*

*"... we are moving from a framework that focuses in the past on known threats, to a more flexible framework based on capabilities to defend ourselves from shifting and uncertain threats ... from a focus simply on programs and platforms, to a focus on results ... from segmented information and closed information architecture, to network information and open architectures ... ... and from what is called "deliberate planning" ... to ..."adaptive planning."*

Source: DepSecDef Keynote on Transformation

to The Heritage Foundation, 27 Feb 2004

*"The OSJTF's modular, open systems approach is a key enabler in the Department's focus on joint architectures and evolutionary approach to weapon systems acquisition. All acquisition programs should employ a modular, open systems approach."*

Enhanced Interoperability

MOSA

Reduced Cycle T[ime]

Reduced Life Cycle Cost

Delivering effective combat capabilities

# Military Trends: Losing Market Leverage

## Declining Defense Spending

### Defense Outlays As a Share of Gross Domestic Product
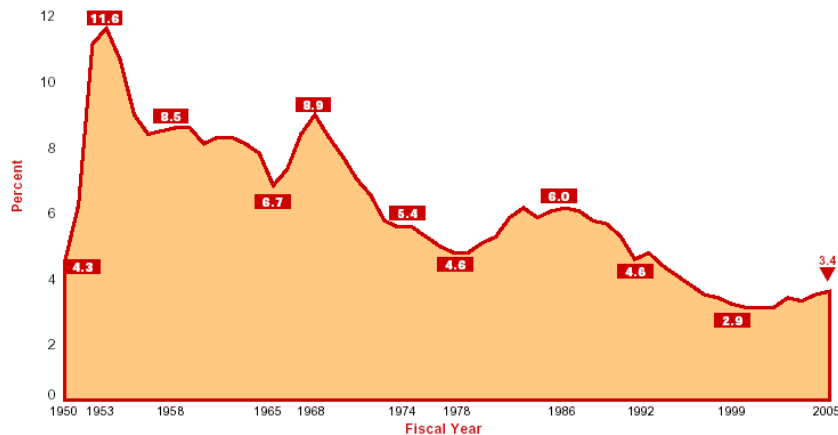


**DOD Budget (as % of GDP) Near Its Lowest Level Since After WWII!**

*Source: Air Force Magazine, April 2004 (data from US Department of Defense)*

## Decreasing Market Share

### 2003 Total Worldwide Merchant Semiconductor Usage
#### Total $140.7 Billion



Computer 53%

Consumer 17%

Communications 15%

Military <1%

Auto 5%

Industrial 9%
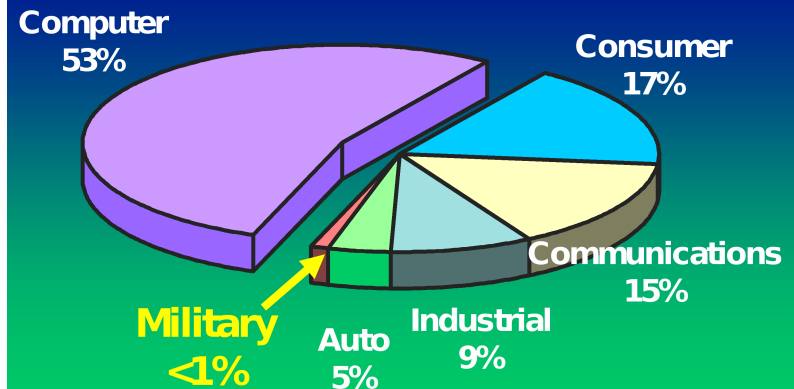
Source: Semiconductor Industry Association

- **DoD Has Minimal Impact in the Electronics Industry**
- **Obsolescence is Market Driven**
  - It Won't Go Away
  - We Can't Change The Environment
- **Results in Unaffordable Non-Recurring engineering (NRE)**
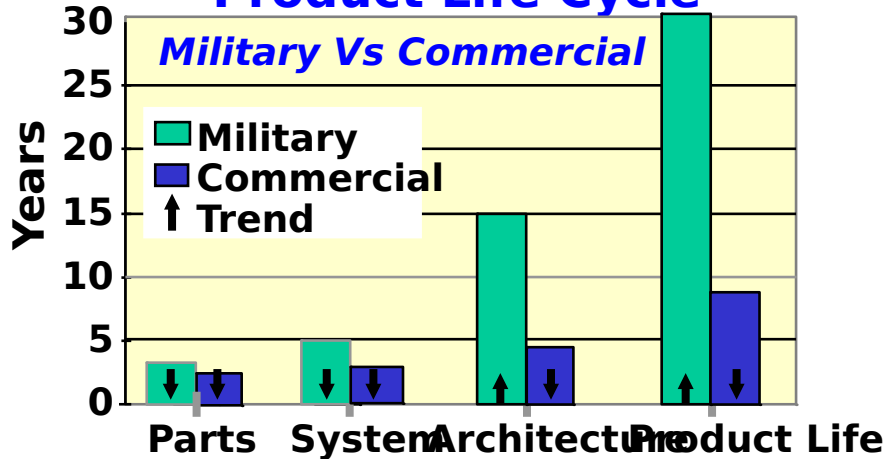
# Commercial Technology Trends: Reduced Cost & Cycle Time
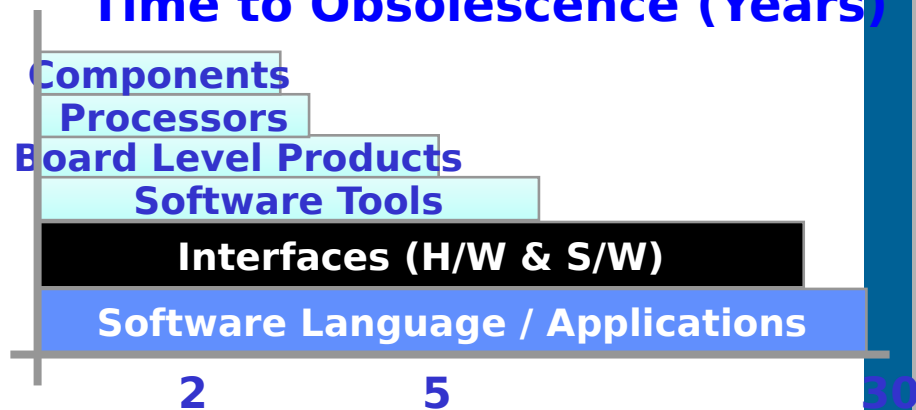
## Technology Evolution

**Device Density (Transistors Per Die)**

1B
100M
10M
1M
100K
10K
1K

Technology Growth:
- Doubles Every 2 Yrs
- Cost/Part Decreases
- 10,000:1 in 20 Yrs

1Gb
256Mb
64Mb
16Mb
4Mb
1Mb
256Kb
64Kb
16Kb
4Kb
1Kb

G12
G11
G10
500K
300K

Merced
Pentium IV*
Pentium III*
Pentium II
Pentium Pro
Pentium
80486
80386
80286
8086
8085
8080
8008
4004

- Intel Processors - 38%/yr
- DRAM - 49%/yr
- ASIC - 50%/yr

65 70 75 80 95 90 95 00 05

## Shorter Product Lifetimes

**Production (Millions)**

45
40
35
30
25
20
15
10
5
0

Source: Dataquest Inc.

Pentium
486
386
286
Pro
PII
PIII

85 87 89 91 93 95 97 99

## Product Life Cycle

*Military Vs Commercial*

**Years**

30
25
20
15
10
5
0

- Military
- Commercial
- ↑ Trend
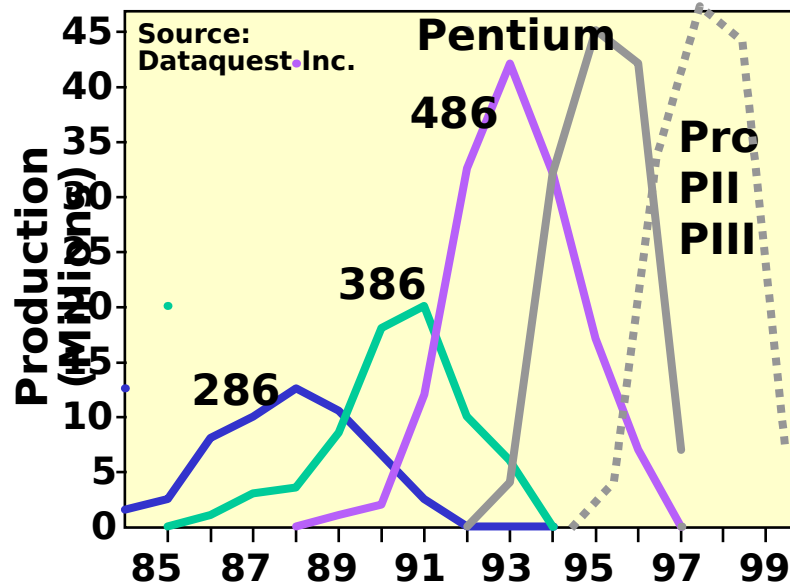
Parts  System  Architecture  Product Life

## Time to Obsolescence (Years)

Components
Processors
Board Level Products
Software Tools
Interfaces (H/W & S/W)
Software Language / Applications

2    5

30

# What Does Interoperability Mean?

- Multiple aspects of end-to-end interoperability
  - Inner loop: Do the terminals recognize each others signals?
  - Outer loop: Do the user's impressions of the information coincide?



**Platform B - C2**

**Platform A - F-1**

User | Display | CPU | Terminal | Terminal | CPU | Display | User

**Terminal to Terminal**

**Processor to Processor**

**Display to Display**

**User to User**
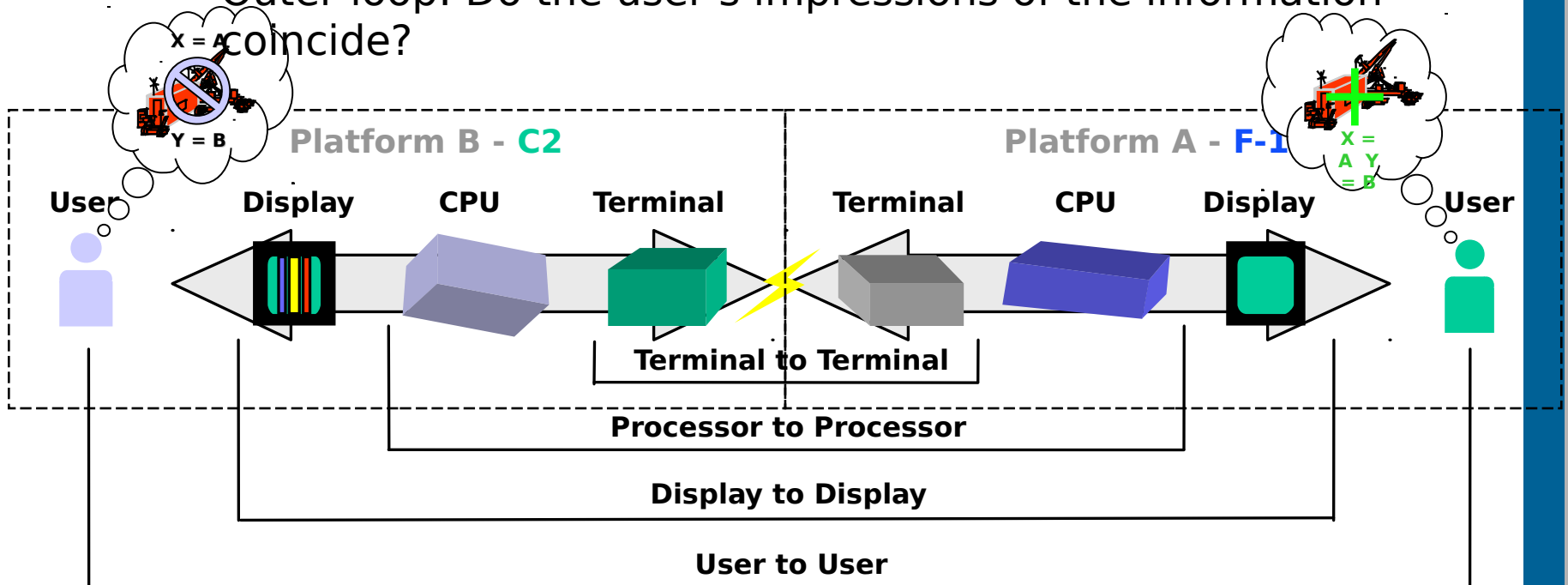
*Interoperability:  Ability to Exchange Information so as to Enable Cooperative Actions for Mission Accomplishment*

# MOSA Defined

**An integrated business and technical strategy that:**

- provides an **enabling environment**,
- employs a **modular design** and, where appropriate,
- defines **key interfaces,**
- using **widely supported, consensus-based (i.e., open) standards** that are published and maintained by a recognized industry standards organization
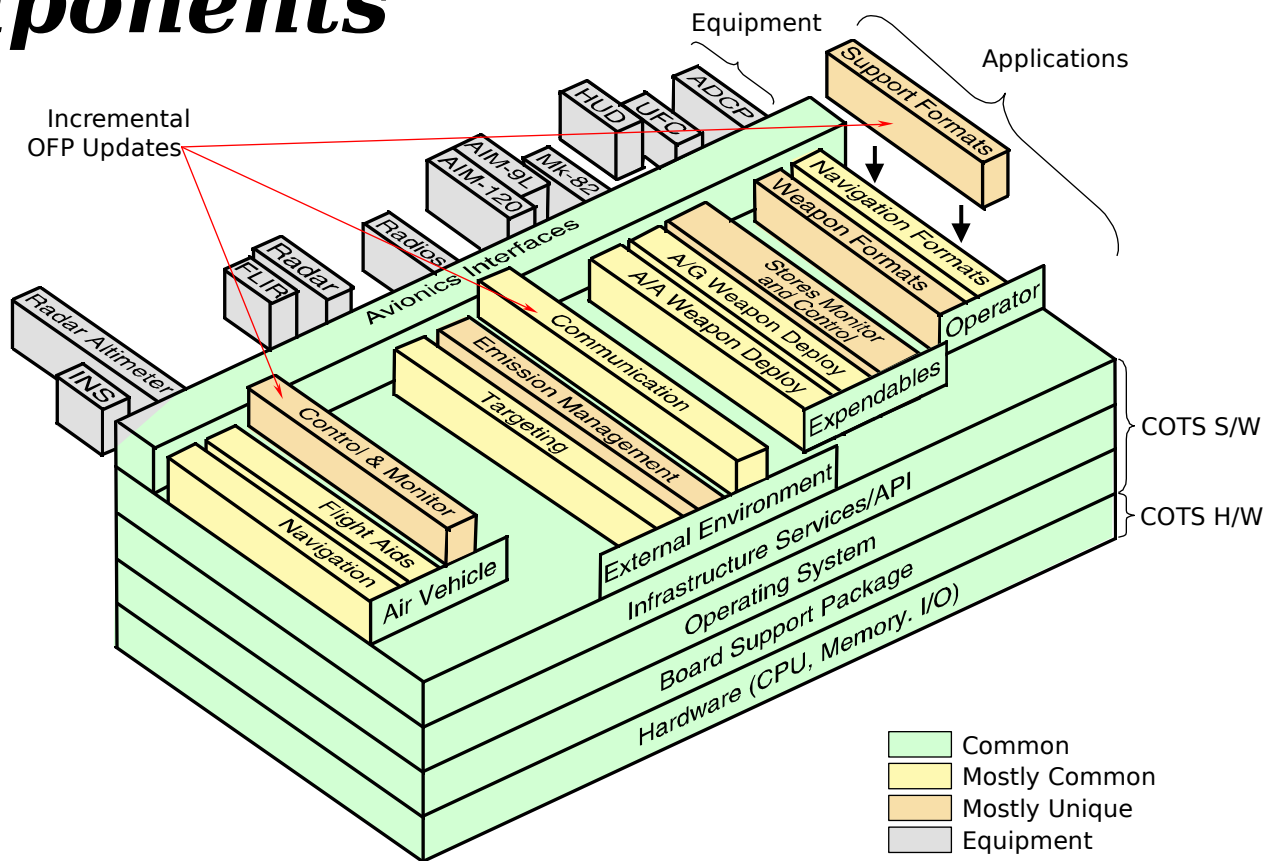- and uses **certified conformant** products.

# Open Systems Concepts: Interfaces
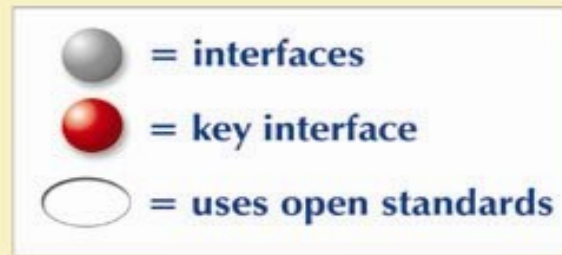


DoD focus is on the **Interfaces**

Producers choose the **Implementation**
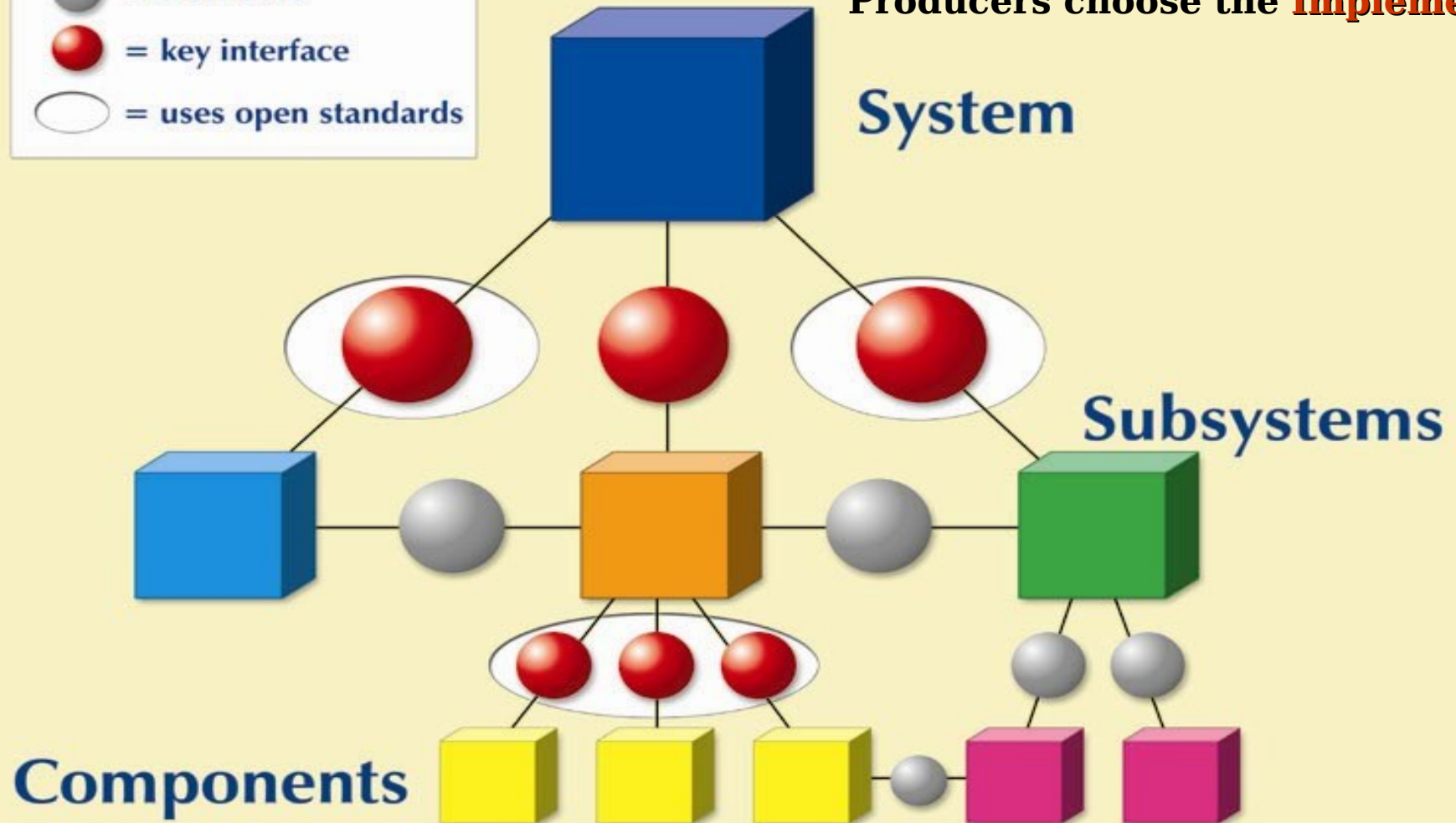
# Open Interfaces Isolate Hardware and Software Components



**The Layered, Object-Oriented Design Provides O&S Savings by Facilitating Reusable Applications and Permitting Software Changes & Hardware Updates With Minimal Retesting**
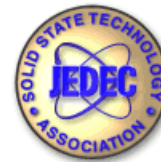
# *Public Law 104-113*

- **With regard to non-government standards, Section 12d states:**

**(1)  IN GENERAL. - Except as stated in paragraph (3) [exceptions] of this section, all Federal Agencies and departments shall use technical standards that are developed or adopted by voluntary consensus standards bodies, using such technical standards as a means to carry out policy objectives or activities determined by the agencies and departments.**

**(2)   CONSULTATION; PARTICIPATION.  In carrying out paragraph (1) of this subsection, Federal agencies and departments shall consult with voluntary, private sector, consensus standards bodies and shall, when such participation is in the public interest and is compatible with agency and departmental missions, authorities, priorities, and budget resources, participate with such bodies in the development of technical standards.**
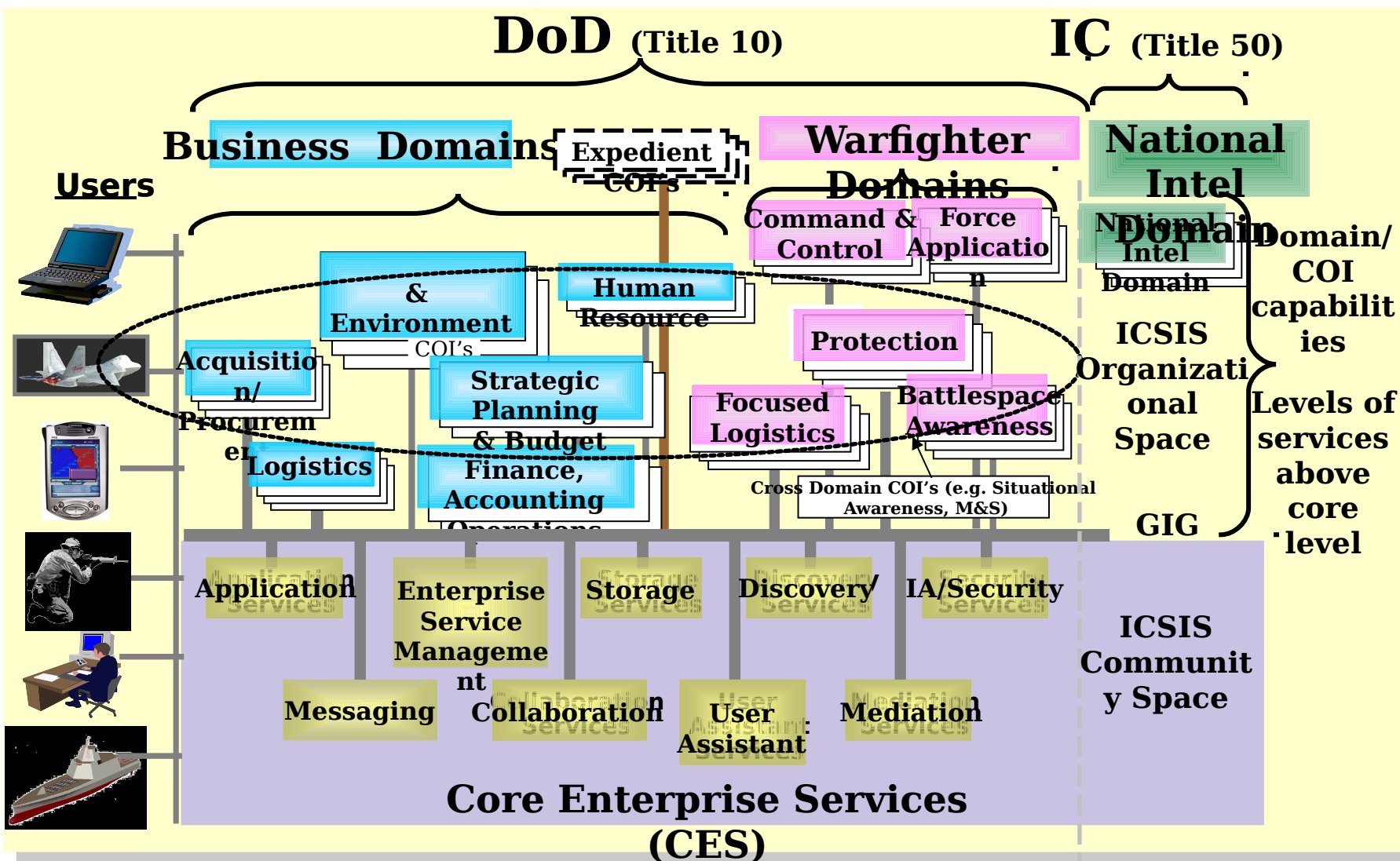
# Standards Bodies and Consortia

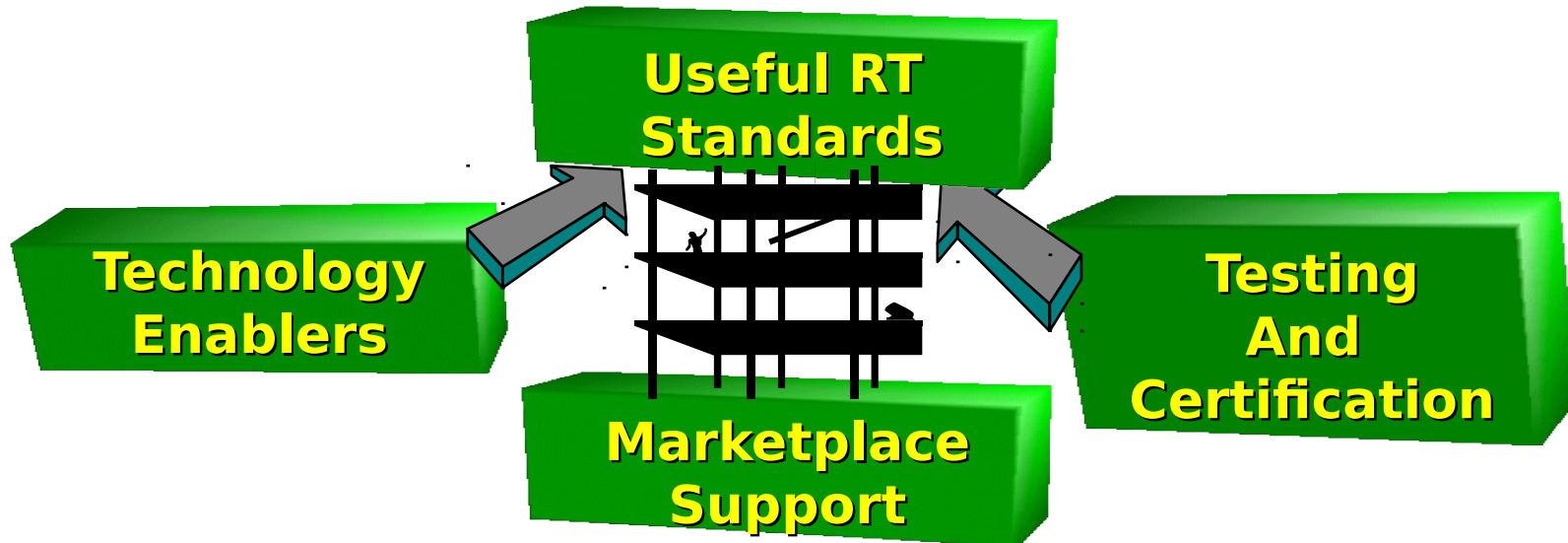# *Influencing Warfighter Standards*



**DoD** **(Title 10)**    **IC** **(Title 50)**

**Business Domains**    **Warfighter Domains**    **National Intel Domain**

Expedient COIs

**Users**

Command & Control · Force Application

National Intel Domain

Domain/ COI capabilities

& Environment

Human Resource

COI's

Protection

ICSIS Organizational Space

Acquisition/ Procurement

Strategic Planning & Budget

Focused Logistics

Battlespace Awareness

Levels of services above core level

Logistics

Finance, Accounting Operations

Cross Domain COI's (e.g. Situational Awareness, M&S)

GIG

| Application | Enterprise Service Management | Storage | Discovery | IA/Security |
|---|---|---|---|---|
| Messaging | Collaboration | User Assistant | Mediation | |

ICSIS Community Space

**Core Enterprise Services (CES)**

# Real-Time & Embedded Systems Forum – Vision and Mission

**Useful RT Standards**

**Technology Enablers**

**Testing And Certification**

**Marketplace Support**
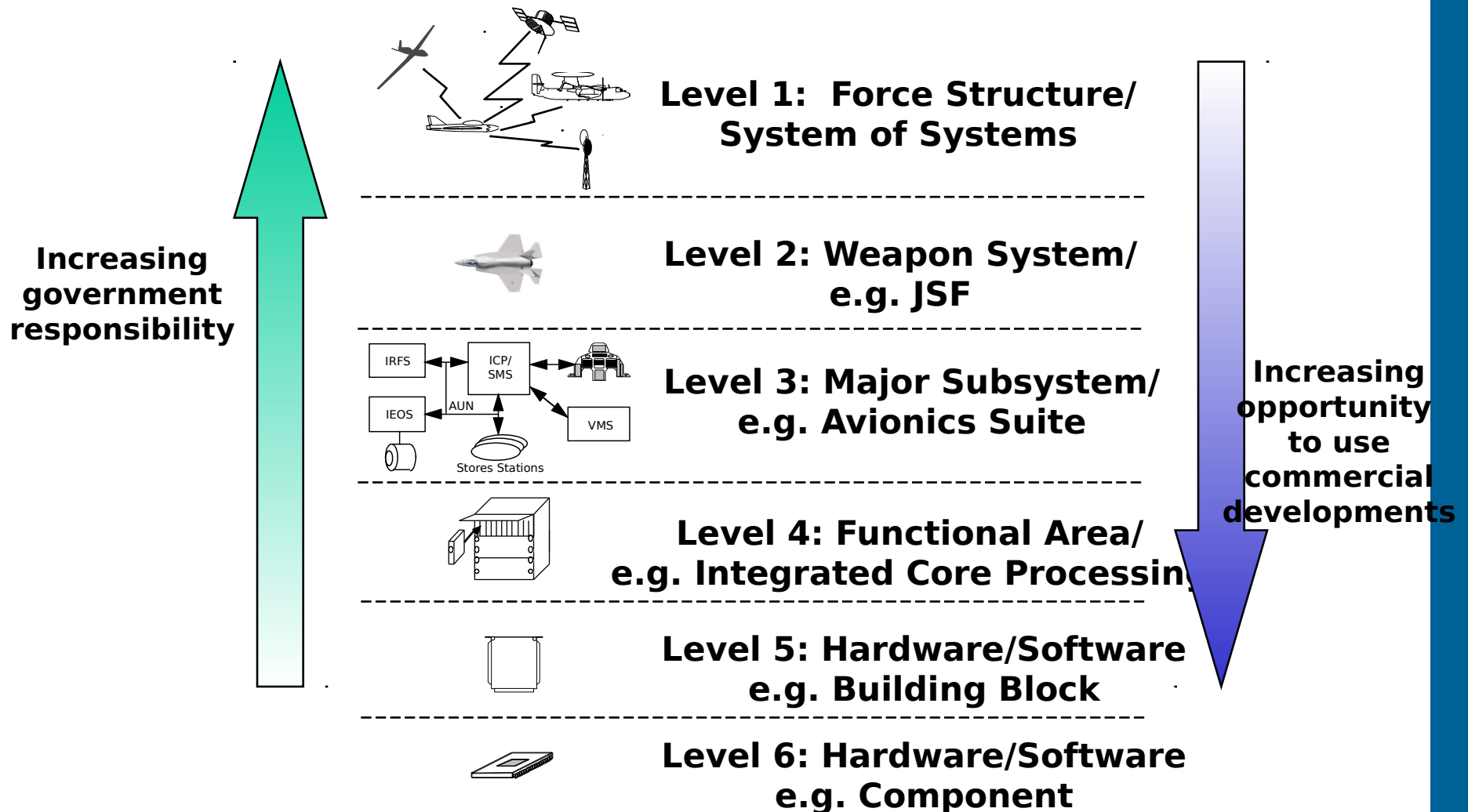
Improve the time and cost, to market adoption, of real-time and embedded solutions by providing a forum where we can share knowledge and integrate open initiatives, and certify approved products and processes
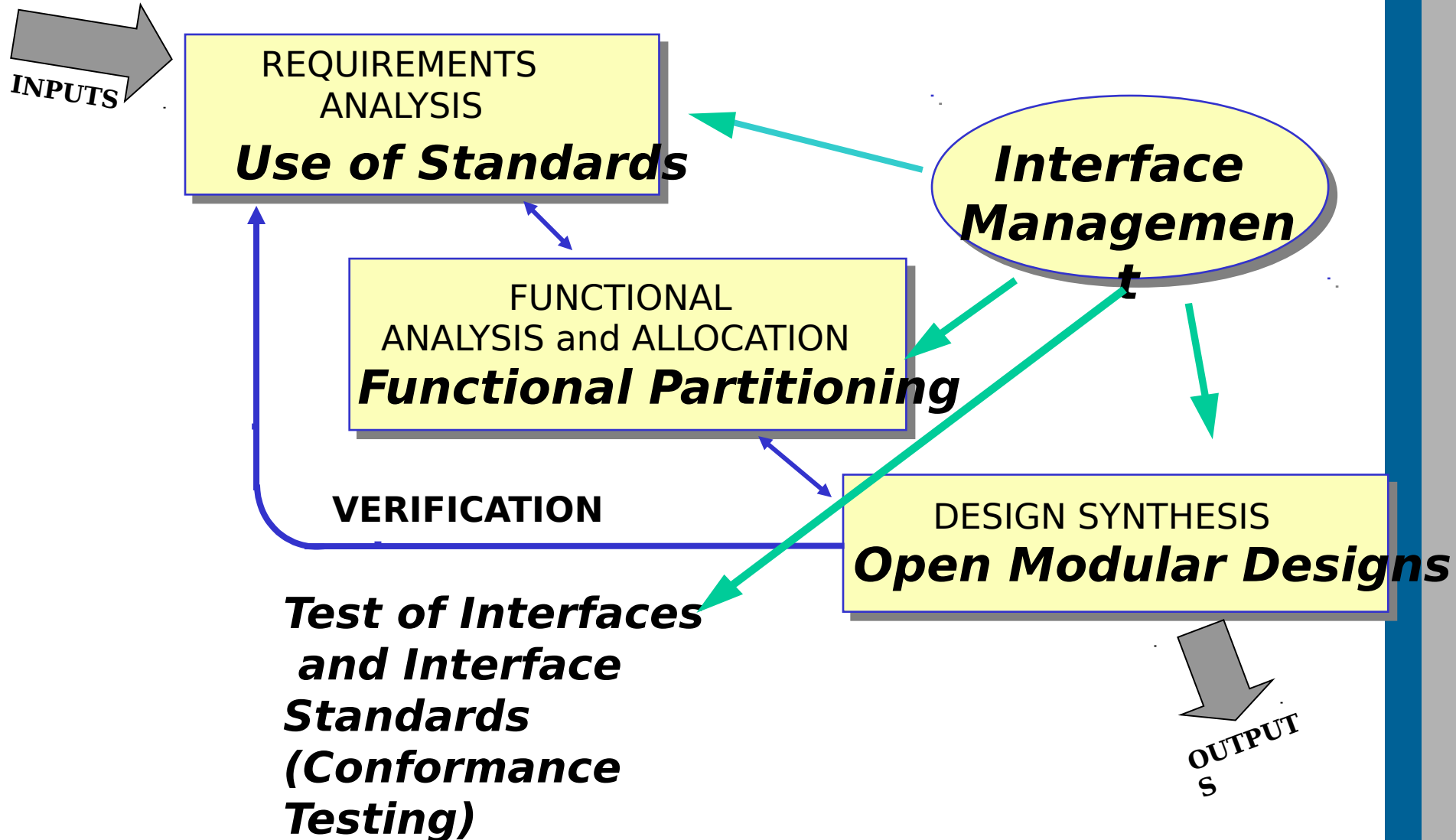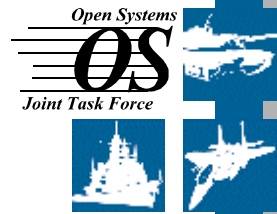
www.opengroup.org/rtforum

# Where does MOSA Apply?

**Level 1: Force Structure/ System of Systems**

**Level 2: Weapon System/ e.g. JSF**

**Level 3: Major Subsystem/ e.g. Avionics Suite**

IRFS

ICP/ SMS

IEOS

AUN

VMS

Stores Stations

**Level 4: Functional Area/ e.g. Integrated Core Processing**

**Level 5: Hardware/Software e.g. Building Block**

**Level 6: Hardware/Software e.g. Component**

**Increasing government responsibility**

**Increasing opportunity to use commercial developments**

# Architecture Views:
# (Genesis of Joint Integrated Architectures)

**Users Define**

**Industry Creates**

**Operational View**

**Systems Engineering**

**Technical View**

*Employment Strategy*

*The Building Codes*

*Programs Build*

**Domain Product Lines**

*The Building Blocks (Products, Services, Tools, Processes)*
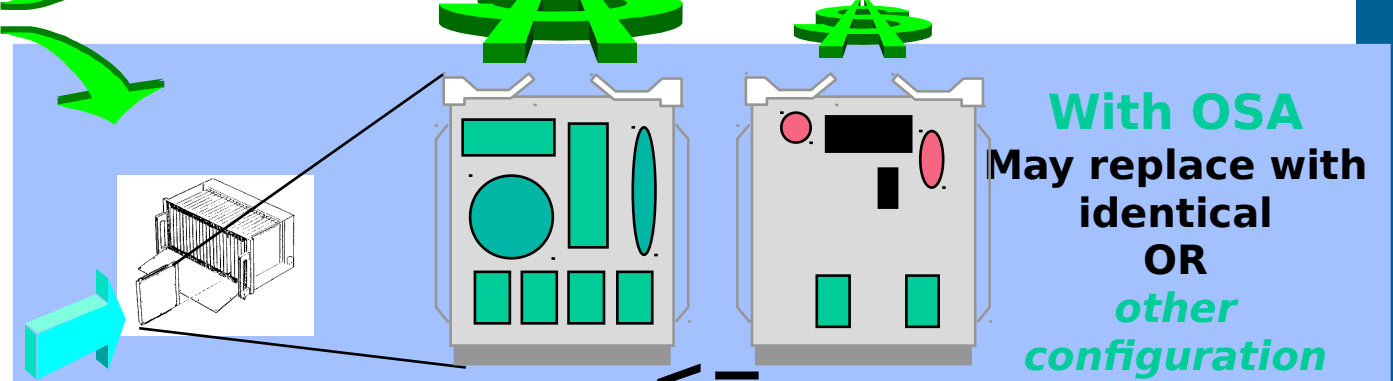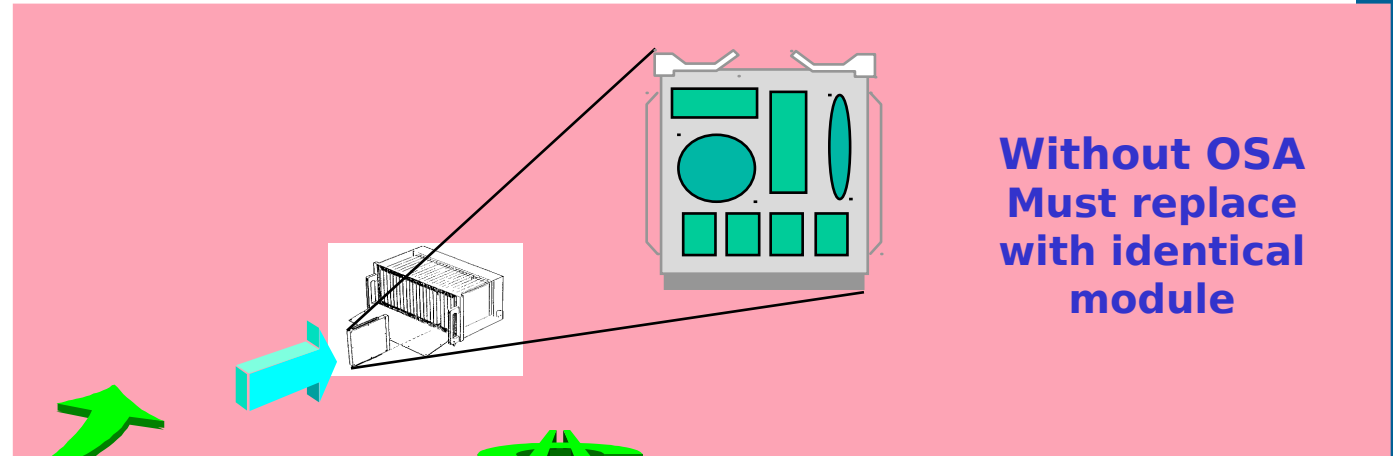
**System View**

**Weapon Systems**

*The Blueprint*

# Designing Open Systems Demands the Discipline of the SE Process

INPUTS

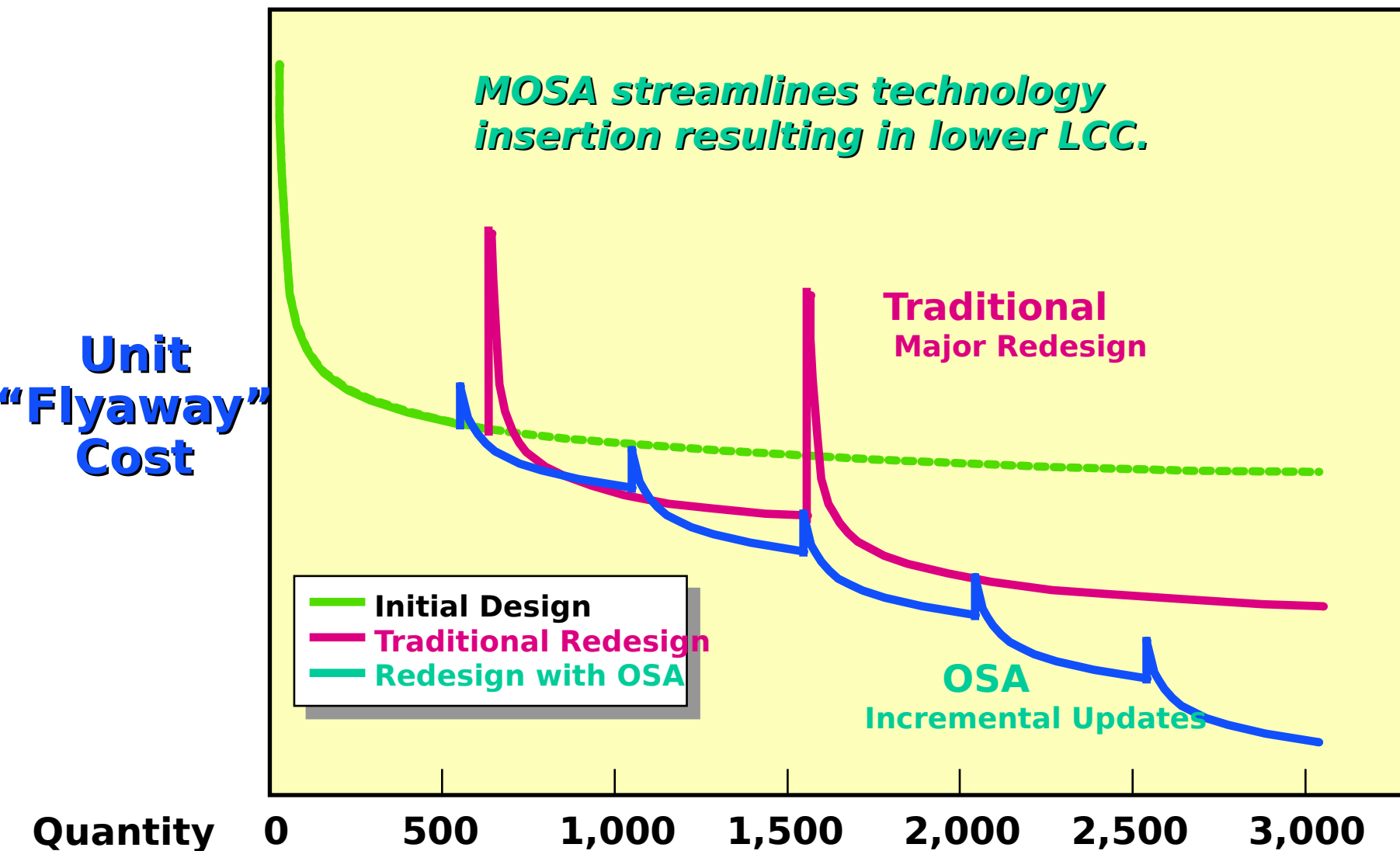REQUIREMENTS ANALYSIS
**Use of Standards**

**Interface Management**

FUNCTIONAL ANALYSIS and ALLOCATION
**Functional Partitioning**

VERIFICATION

DESIGN SYNTHESIS
**Open Modular Designs**

**Test of Interfaces and Interface Standards (Conformance Testing)**

OUTPUTS

# Logistics Support Considerations:
## Module Replacement or Upgrade?

**Module Fails**

**Remove Module**

**Without OSA**
**Must replace with identical module**

**With OSA**
**May replace with identical**
**OR**
*other configuration*

<=
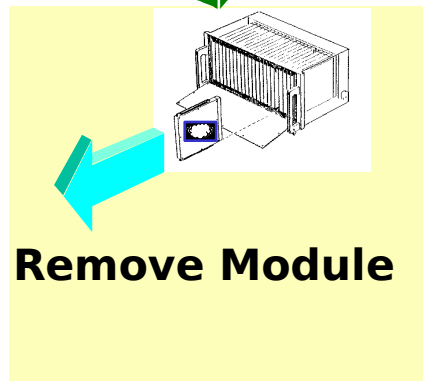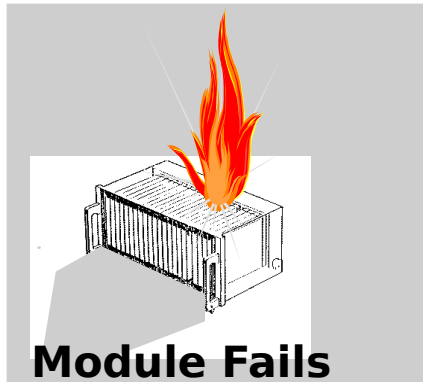
- **Module interface rigorously controlled**
  » New interface must be backward compatible
- **Numerous operational configurations possible**
  » **Not all possible configurations explicitly tested**

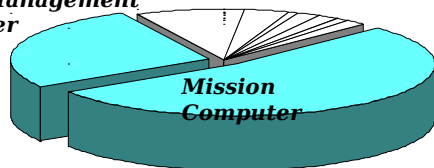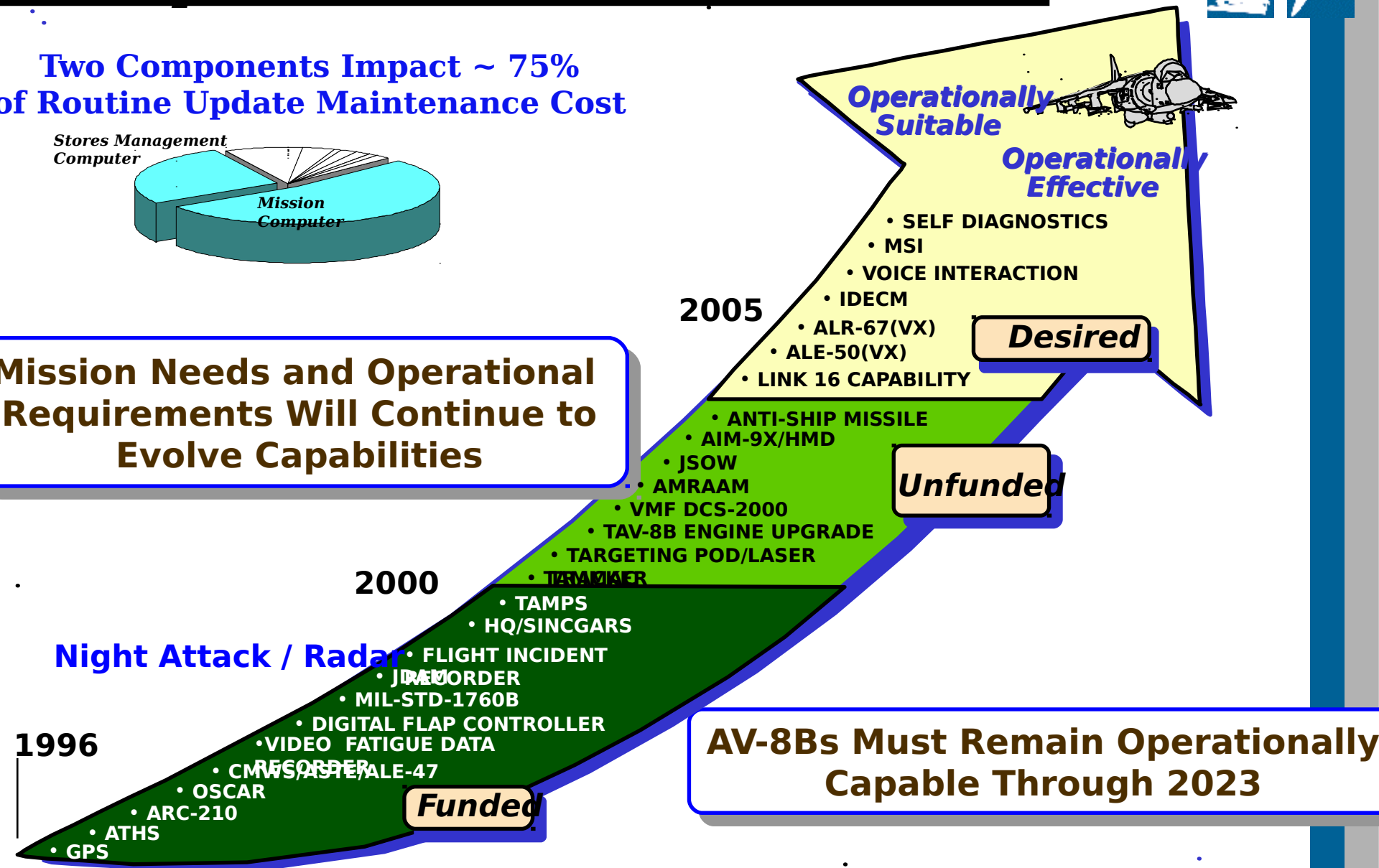# Effect of MOSA Periodic Technology Insertion on System Costs



*MOSA streamlines technology insertion resulting in lower LCC.*

Unit "Flyaway" Cost

Traditional
**Major Redesign**

OSA
**Incremental Updates**

Legend:
- Initial Design
- Traditional Redesign
- Redesign with OSA

Quantity: 0   500   1,000   1,500   2,000   2,500   3,000

# Example: AV-8B Operational Requirements



**Two Components Impact ~ 75% of Routine Update Maintenance Cost**

*Stores Management Computer*

*Mission Computer*

**Operationally Suitable**

**Operationally Effective**

- SELF DIAGNOSTICS
- MSI
- VOICE INTERACTION
- IDECM
- ALR-67(VX)
- ALE-50(VX)
- LINK 16 CAPABILITY

**2005**

**Desired**

**Mission Needs and Operational Requirements Will Continue to Evolve Capabilities**

- ANTI-SHIP MISSILE
- AIM-9X/HMD
- JSOW
- AMRAAM
- VMF DCS-2000
- TAV-8B ENGINE UPGRADE
- TARGETING POD/LASER
- TRACKER

**Unfunded**

**2000**

- TAMPS
- HQ/SINCGARS
- FLIGHT INCIDENT RECORDER
- JDAM
- MIL-STD-1760B
- DIGITAL FLAP CONTROLLER
- VIDEO FATIGUE DATA RECORDER
- CMWS/ASPIE/ALE-47
- OSCAR
- ARC-210
- ATHS
- GPS

**Night Attack / Radar**

**Funded**

**1996**

**AV-8Bs Must Remain Operationally Capable Through 2023**

# A Real-World MOSA Example

- **What**
  - Predator UAV was augmented with Hellfire missile in just over 30 days for rapid deployment in Afghanistan.
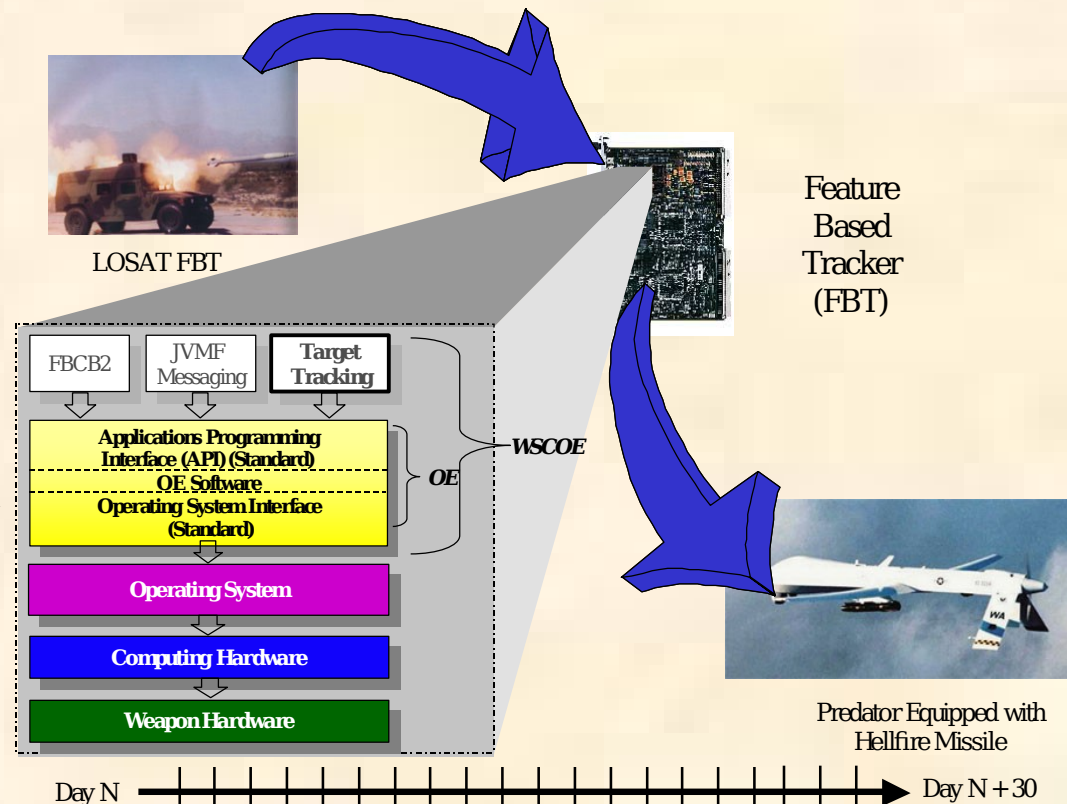- **How**
  - Critical target tracking software was easily rehosted from LOSAT (Line of Sight Anti-Tank) computing environment to Predator's because it was built upon the Army's open Weapon System COE API.
  - The WSTAWG COE specifies common services for managing the 1553 bus and for handling digital video.
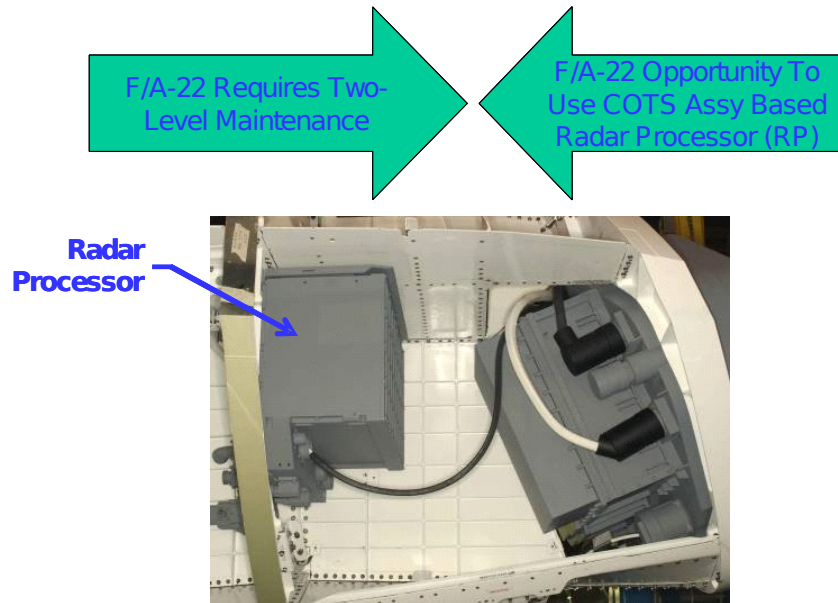
**Resulted in:**

- A New Capability - fielded rapidly
- Significant Cost Avoidance - 75% of typical software development costs
- Enhanced Interoperability - by re-using a proven weapon systems product

**Enabled by MOSA using:**

- Modular Design
- Key Interfaces
- Open Standards

LOSAT FBT

Feature Based Tracker (FBT)

| FBCB2 | JVMF Messaging | **Target Tracking** |
|---|---|---|

**Applications Programming Interface (API) (Standard)**

OE Software

**Operating System Interface (Standard)**

*WSCOE*

*OE*

**Operating System**

**Computing Hardware**

**Weapon Hardware**

Predator Equipped with Hellfire Missile

Day N ──────────────── Day N + 30

# F/A-22 Radar Processor (RP) Example



**F/A-22 Requires Two-Level Maintenance**

**F/A-22 Opportunity To Use COTS Assy Based Radar Processor (RP)**
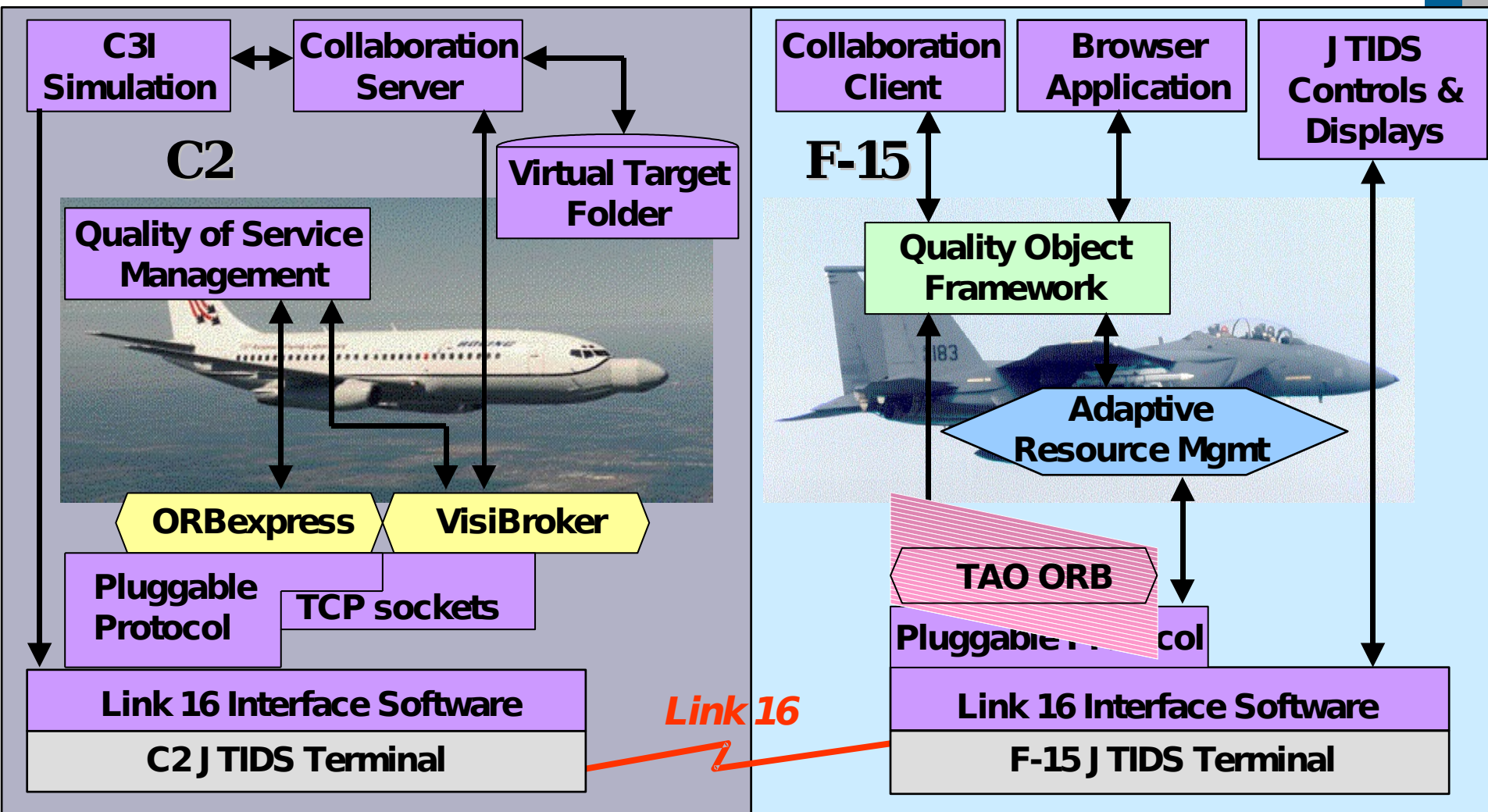
**Radar Processor**

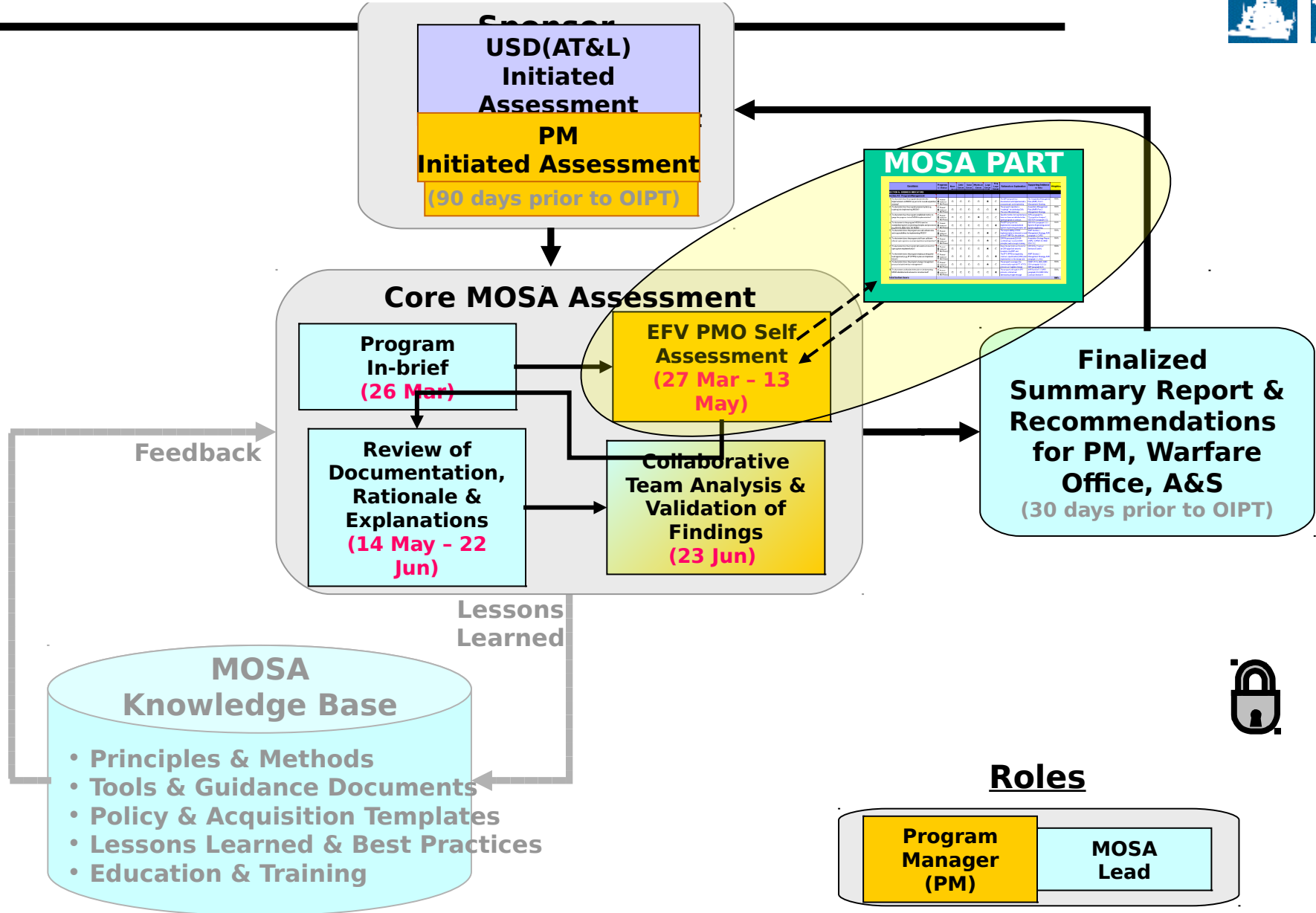Compelling cost savings available by using COTS assembly based radar processor (RP) developed for other platforms.

- Two-Plus-Level (Send box to depot) maintenance strategy
- COTS Modules do not support Card/Module Level Remove & Repair (R&R)
- RP Fits available volume but does not fit through access opening
- Inability to R&R cards turns a 1.5 hour maintenance task Into a 24 hour maintenance task
- Structural modification will be required to achieve an acceptable COTS implementation
- Structural modification would not be required, and far greater cost savings would be possible,
  if COTS modules were available with ESD/handling protection

# Weapon System Open Architecture Demonstration: Technology Insertion for Collaborative Time Critical Target Prosecution

**C2**

- C3I Simulation
- Collaboration Server
- Virtual Target Folder
- Quality of Service Management
- ORBexpress
- VisiBroker
- Pluggable Protocol
- TCP sockets
- Link 16 Interface Software
- C2 JTIDS Terminal

**F-15**

- Collaboration Client
- Browser Application
- JTIDS Controls & Displays
- Quality Object Framework
- Adaptive Resource Mgmt
- TAO ORB
- Pluggable Protocol
- Link 16 Interface Software
- F-15 JTIDS Terminal

**Link 16**

# .. *MOSA Assessment Process*

**Sponsor**

**USD(AT&L) Initiated Assessment**

**PM Initiated Assessment**

**(90 days prior to OIPT)**

**MOSA PART**

**Core MOSA Assessment**

**Program In-brief (26 Mar)**

**EFV PMO Self Assessment (27 Mar – 13 May)**

**Feedback**

**Review of Documentation, Rationale & Explanations (14 May – 22 Jun)**

**Collaborative Team Analysis & Validation of Findings (23 Jun)**

**Finalized Summary Report & Recommendations for PM, Warfare Office, A&S (30 days prior to OIPT)**

**Lessons Learned**

## MOSA Knowledge Base

- **Principles & Methods**
- **Tools & Guidance Documents**
- **Policy & Acquisition Templates**
- **Lessons Learned & Best Practices**
- **Education & Training**

## Roles

**Program Manager (PM)**

**MOSA Lead**

# System-of-Systems Architectures Development

PRINCIPAL DEPUTY UNDER SECRETARY OF DEFENSE
3015 DEFENSE PENTAGON
WASHINGTON, DC 20301-3015

DEC 18

ACQUISITION,
TECHNOLOGY AND
LOGISTICS

MEMORANDUM FOR VICE CHAIRMAN OF THE JOINT CHIEFS OF STAFF
ASSISTANT SECRETARY OF THE ARMY (RD&A)
ASSISTANT SECRETARY OF THE NAVY (RD&A)
ASSISTANT SECRETARY OF THE AIR FORCE
(ACQUISITION)
DIRECTOR, DEFENSE RESEARCH AND ENGINEERING
DEPUTY UNDER SECRETARY OF DEFENSE
(LOGISTICS)
DIRECTOR, STRATEGIC AND SPACE SYSTEMS
DIRECTOR, TACTICAL WARFARE SYSTEMS
ACQUISITION EXECUTIVE, US SPECIAL OPERATIONS
COMMAND

SUBJECT: Extension of the Open Systems Joint Task Force (OSJTF)

As part of our efforts to modernize the Department of Defense, the OSJTF has been moved into the newly formed Systems Integration Directorate as part of Defense Systems. The OSJTF's modular, open systems approach is a key enabler in the Department's focus on joint architectures and evolutionary approach to weapon systems acquisition.

Although the Services and Agencies, with the help of the OSJTF, are working toward modular, open systems, work remains at the system-of-systems level. I expect the Task Force to play an important role in achieving joint architectures by applying a modular, open systems approach at the system-of-systems level. Therefore, I am extending the OSJTF through FY 2005.

I am requesting that each of the military departments continue to provide two staff members to the Task Force. The Task Force will report to me on the progress of implementing modular, open systems within the department, and I will reevaluate the need for continuing it on a periodic basis.

Your assistance is essential in helping us achieve lasting benefits for the Department. My point of contact for this effort is Mr. Aubrey T. Smith at (703)-602-0851 ext.119 or at aubrey.smith@osd.mil.
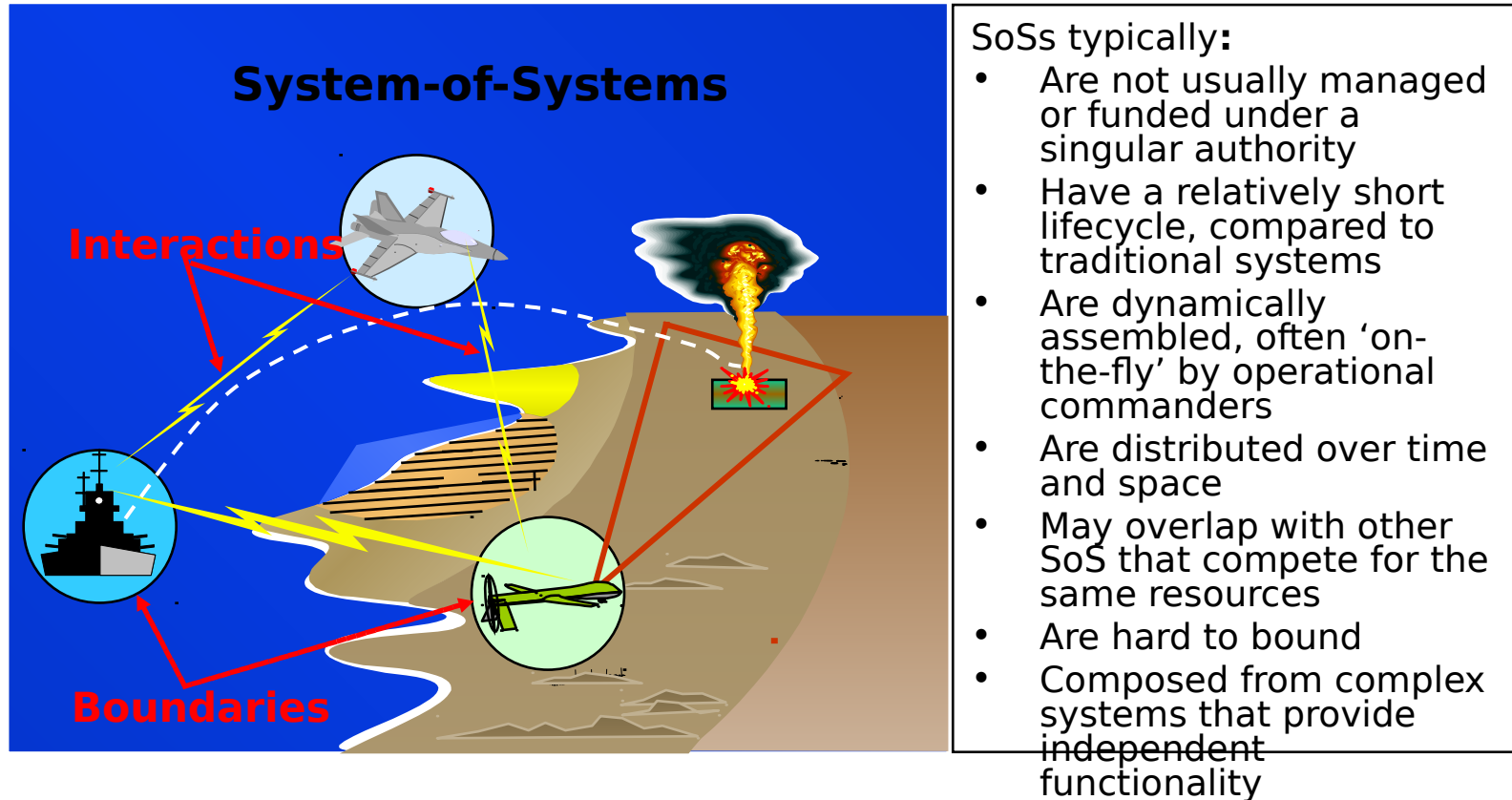
MICHAEL W. WYNNE

*"I expect the Task Force to play an important role in achieving joint architectures by applying a modular, open systems approach at the system-of-systems level."*

# *SoS Modeling Initiative*

## Problems Developing SoS Architecture Views



**System-of-Systems**

Interactions

Boundaries

SoSs typically**:**
- Are not usually managed or funded under a singular authority
- Have a relatively short lifecycle, compared to traditional systems
- Are dynamically assembled, often 'on-the-fly' by operational commanders
- Are distributed over time and space
- May overlap with other SoS that compete for the same resources
- Are hard to bound
- Composed from complex systems that provide independent functionality

- The increased use of architectures, as a basis for making programmatic decisions, raises the bar for their level of consistency, precision and scalability
- It is not always clear how the various SoS architecture views relate to, complement, clash with or integrate with each other

# *SoS Modeling Initiative*
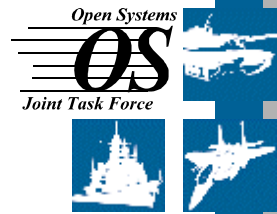
- Objective
  - Determine if modeling is a viable approach for creating SoS architecture views that satisfy requirements of multiple stakeholders
    - Warfighter, Acquirer, Developer, Integrator, Tester

- Approach
  - **Phase I**  (Jun 04 – Aug 04)
    - A series of structured workshops to obtain and vet stakeholder needs and to identify best practices for modeling SoS views
  - **Phase II**  (Oct 04 – Mar 05)
    - Demonstrate the viability of industry modeling standards for SoS views by applying the best practices developed in the workshops to a joint integrated warfare scenario
    - OSJTF will commission this effort as a 'proof of concept'.
  - **Phase III** (Apr 05 –Jun 05)
    - Formalize the migration strategy, actions, timelines and milestones necessary to implement related findings and recommendations

- To realize end-to-end use and interchange of SoS architecture models across all value-chains, there must be
  - A minimal, but extensible schema that all COIs adopt
  - A modular, open and broadly accepted framework to effectively fit together or for plugging-in the various architecture model services
    - Create, store, visualize, query, assemble (or compose), exchange, use, interpret, analyze, execute (or simulate), verify and secure

# What an Open System is...and is not

- **_IS_**

A system that employs modular architecture and uses widely
supported and consensus based standards for its key interfaces

- **IT ENABLES _BUT IS NOT_ NECESSARILY SIMPLY**

**EQUAL TO:**

- Commonality

- COTS

- $F^3I$ (Form, Fit, Function and Interface)

# Modular Open Systems Approach (MOSA)

## Vision

MOSA is an integral part of all acquisition strategies to achieve affordable, evolutionary, and joint combat capability

## Principles

- Establish Enabling Environment
- Employ Modular Design
- Designate Key Interfaces
- Select Open Standards
- Certify Conformance

## Benefits

- ✓ Ease of Change
- ✓ Reduced Total Ownership Cost
- ✓ Reduced Cycle-Time
- ✓ Enabling Joint Integrated Architectures and Interoperability
- ✓ Risk Mitigation

Business    Technical

## Indicators

# How to Contact the OSJTF

Open Systems Joint Task Force

Crystal Mall 3, Suite 104

1851 South Bell Street

Arlington, VA 22202

www.acq.osd.mil/osjtf

(703) 602-0851

(703) 602-3560 FAX

Shortcut to the MOSA Program Assessment and Review Tool (PART):

www.acq.osd.mil/osjtf/html/mosa_assessment.html

# *Questions*

# Definition of Open Systems

A system that implements sufficient open standards  for interfaces, services, and supporting formats to enable properly engineered components to be utilized across a wide range of systems with minimal changes, to interoperate with other components on local and remote systems, and to interact with users in a style that facilitates portability.  An open system is characterized by the following:

> well defined, widely used, non-proprietary interfaces/protocols, and
> use of standards which are developed/adopted by recognized standards bodies or the commercial market place, and
> definition of all aspects of system interfaces to facilitate new or additional systems capabilities for a wide range of applications, and
> explicit provision for expansion or upgrading through the incorporation of additional or higher performance elements with minimal impact on the system.

*(OS-JTF 1998)*